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Farm Sustainability Assessment and Model: Achieving Food Security through the Food Estate Program in North Sumatra

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Abstract: Improving food crop production is critical for achieving food security. The Food Estate (FE) program initiated by the government seeks to accomplish this through extensive and intensive farming practices while taking sustainability into consideration. In this paper, a multidimensional scaling (MDS) approach to determine the status and model of agricultural sustainability of the FE program was adopted. Three scenarios were developed to improve the sustainability status based on primary data from interviews with 50 farmers in Ria-Ria Village, Pollung District, North Sumatra. The findings indicate that the farming status is at a moderate sustainability, and improving all aspects can significantly increase the sustainability value. The study suggests that the government should prioritize the improvement of all aspects to raise the sustainability status of FE farming in order to achieve food security.

Keywords: sustainable assessment; multidimensional scaling; Food Estate program

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1. Introduction

The United Nations predicts that the global population will reach 9.7 billion by 2050, potentially escalating the demand for food. Indonesia, with a population of 270 million people, is located in the Southeast Asian region and must adequately provide for its own food requirements to preserve national food security. Food security includes food availability, accessibility, quality, and safety. Domestic production can increase food availability or importing food commodities may also satisfy the demand. However, burdening the trade balance through excessive food imports may be necessary as some food commodities face a deficit.

For example, from 2018 to 2020, the data indicate a deficit in the export and import trade of rice commodities. However, it is noteworthy to mention that the deficit appears to be decreasing. In 2018, the trade deficit was USD 1,037,128, whereas in 2021 it has been reduced to USD 180,361 [1]. This remarkable reduction is an outcome of the government's arduous efforts to improve national food security. Despite this, Indonesia's current food security condition ranks 63rd out of 118 countries [2].

Joko Widodo's two-term presidency has implemented various policies and programs to achieve national food security. In 2020, the government aimed to achieve food security through the Food Estate (FE) program. The FE program aims to increase production by extending production centres to locations that will specialize in food commodity production. The extension effort involves a substantial land area in multiple regions of Indonesia. There are numerous regions in Indonesia slated to host the FE Program, including Papua

(2,038,951.09 ha), Central Kalimantan (770,601 ha), North Sumatra (30,000 ha), and South Sumatra (235,351 ha) [3].

FE North Sumatra, operational since 2021, is situated in Humbang Hasundutan Regency with a 215-hectare planting area in its first phase. Horticultural commodities, such as shallots, garlic, chillies, and potatoes, are cultivated in the region. It is anticipated that the presence of FE will address the food security situation of North Sumatra, which is presently at the 20th position in the Food Security Index among the 34 provinces [4].

The FE land area, spanning across multiple districts including Humbang Hasundutan, Pakpak Bharat, Central Tapanuli and North Tapanuli, will utilise 30,000 hectares [3]. The initial phase of the project will take place in Humbang Hasundutan Regency, focusing on horticultural commodity farming. Development of farming on new land must consider sustainability aspects pertaining to the environment, society, and economy.

The topic of environmental sustainability is the subject that many parties give the most attention to since it involves new land that has the potential to harm ecosystems, soil conditions, animals, and plants that inhabit the forest. Specifically, the venture plans to utilize 11,000 hectares of protected forest, 18,252 hectares of production forest, and 785 hectares of limited production forest [3]. Environmental activists have criticised the program for discussing the FE program during the era of Susilo Bambang Yudhoyono, the Merauke Integrated Food and Energy Estate (MIFEE), which was viewed as unsuccessful. During that time, a large amount of forest land was cleared for agriculture.

Sustainability is evaluated based on economic factors, with income being one such indicator. Farmers' income is impacted by the price and volume of production, which can increase profitability [5,6]. Initial production results at the FE site, such as shallot and chilli plants, were below the national productivity levels. Based on data obtained from Coordinating Ministry for Martime and Investment Affairs show that Shallots yielded 1.86 tonnes/ha and red chillies averaged 17.77 tonnes/ha [7], compared to the national productivity of 12.49 tonnes/ha for shallots. Considering that, [8] states that sustainable agricultural development can be achieved by increasing the productivity and income of farmers whose livelihoods depend on agricultural products.

Low agricultural productivity can be attributed to several factors including soil conditions [9], water availability and weather patterns [10], and land ownership [11]. These factors have the potential to result in crop failures and financial losses for farmers, despite the input subsidies provided by the government to FE farmers in the form of seeds, agricultural machinery, fertilisers and pesticides. These losses have a direct impact on the farmers' income. This economic issue has raised concerns for multiple stakeholders and raises questions about the long-term viability of the FE program since it has not successfully improved farmers' earnings.

In addition, social issues may emerge within the community, such as disputes over land tenure. In the MIFEE scheme, the local community partially rejected the program due to uncertainties around land ownership [12]. Social dynamics and interactions may result in differing opinions among farmers participating in the FE program. Pros and cons relating to the sustainability of FE have already been discussed; while some farmers believe the FE program is advantageous, others do not share this view.

Research on the current Further Education (FE) program remains limited to an initial review that lacks depth on the sustainability of the program. Ref. [13] discusses the FE program as a national resilience strategy in the COVID-19 pandemic era; however, this research utilises a qualitative approach that is still restricted to a literature review only. They have not evaluated the impact of the FE program as it had not yet been implemented at the time of their study. Ref. [14] investigated the economic feasibility of the FE program, but did not assess environmental and social factors. Research evaluating the sustainability of FE programs from economic, social, and environmental perspectives has been conducted, however, only for FE programs in Central Kalimantan [15].

Sustainability research in agriculture, such as that conducted by [16], indicates the interconnectedness of every economic, social, and environmental aspect of farming activities.

The research indicates that sustainability should be evaluated from multiple perspectives. Nevertheless, a number of sustainability studies in agriculture focus just on three to five aspects. This study will assess seven aspects of sustainability, specifically economic, social, environmental, institutional, technological, marketing, and cultural, to offer more precise and comprehensive explanations for providing food security policy recommendations.

Based on issues within the FE program and the progress of sustainability research, this paper aims to determine the sustainability status of FE program farms using seven aspects of sustainability, and to model alternative scenarios to improve the sustainability of FE program farms in North Sumatra.

2. Materials and Methods

2.1. Research Design

This paper employed a quantitative research design to assess and define the sustainability of farming and develop a strategy model for improving farming sustainability. The Multidimensional Scaling (MDS) approach was used in conjunction with the Multiple-aspect Sustainability Analysis (MSA) software (Version 2.0.756, Bogor, West Java, Indonesia).

2.2. Respondents

This paper is based on the North Sumatra Food Estate in Pollung District, Humbang Hasundutan Regency. The sample for this research comprised 50 FE farmers. The Coordinating Ministry of Maritime Affairs and Investment Team provided the number of farmers in the population.

2.3. Data Collection

The research employs primary data, consisting of economic, social, environmental, institutional, technological, marketing, and cultural indicators in the form of ordinal data. Technical term abbreviations are explained upon first use. The language is clear and objective, using formal register and balanced expressions. The text adheres to a conventional academic structure, with consistent citation and appropriate use of footnotes. The grammar and spelling are correct. Economic aspects utilise seven factors, social aspects utilise six factors, environmental aspects utilise nine factors, institutional aspects utilise five factors, technological aspects utilise seven factors, marketing aspects utilise five factors, and cultural aspects utilise six factors. So, a total of 45 factors were employed to assess sustainability for this study.

Data on the seven aspects of sustainability were collected through direct interviews with farmers using a structured questionnaire. Sessions with farmers were conducted either at a central location or at their homes and fields. Interviews were conducted using Rapid Appraisal Methods and data collection was carried out over the course of one month spent in the field.

2.4. Data Analysis

2.4.1. Determining the Sustainability Status of Farms

The sustainability status was evaluated via the Multidimensional Scaling (MDS) approach, utilizing the Multipleaspect Sustainability Analyses (MSA) software that requires a licensed access. MSA software, distinct from RAP-Farm, is more convenient to operate, capable of providing graphical data output for each aspect.

Seven aspect input data with 45 factors using an ordinal scale are processed by the MSA software. The data will undergo software processing to determine its sustainability status using a range of scales selected by the researcher. The sustainability status values utilized are given as per [17]: (1) an index score ranging from 0 to 0.4 is indicative of low sustainability, (2) an index score ranging from 0.41 to 0.67 indicates moderate sustainability, and (3) an index score of $\geq$0.68 denotes high sustainability.

2.4.2. Modelling Farm Sustainability Scenarios

The implementation of a scenario model is proposed to enhance farm sustainability. The MSA software was utilized to create these scenarios, with a maximum limit of three. The indicators with the lowest sustainability scores were identified and subsequently improved by increasing their value scores.

Given that the economic and cultural aspects displayed the weakest sustainability status, the three scenarios considered in this study are focused on addressing these areas.

1. In the first scenario, improvements in economic aspects can be seen through indicators such as greater availability of agricultural insurance, processing industries and farming capital. The scores of the three indicators have been increased by one level as they previously scored zero.
2. In the second scenario, cultural aspects can be improved by indicators such as communal work, farming orientation and understanding
3. In the third scenario, there is improvement of all aspects through indicators of availability of processing industries, government subsidies, agricultural insurance (economic aspects), indicators of standardised land rental costs, knowledge of sustainable agriculture and profit-sharing mechanisms (social aspects), indicators of extension frequency, land conversion extension and farmer group conflicts (institutional aspects), indicators of technology adoption, technology relevance and farmer response to technology (technological aspects), indicators of promotional activities, price knowledge, and relationships with consumers (marketing aspects) and indicators of communal work, farming orientation and understanding of agricultural culture (cultural aspects).

3. Results

3.1. Farm Sustainability Status of the Food Estate Program in North Sumatra

The sustainability of FE farming pertains to all farming activities from cultivation to marketing. However, it does indicate whether or not the farming activities carried out by the farmers meet the sustainability indicators. If the indicators are not met, the second part suggests scenarios to improve the sustainability status of FE farming.

Table 1 displays the sustainability status of farming for each aspect and the overall average. The sustainability rating for FE farms has an average score of 50.93, indicating "moderate sustainability". Nonetheless, the economy and culture aspects scored below 50, while the environmental aspect received the highest sustainability rating with a score of 72.22.

Table 1. Sustainability status of North Sumatra FE farms.

No	Aspects	Existing
1	Economy	47.57
2	Social	50
3	Environment	72.22
4	Institutions	50
5	Technology	50
6	Marketing	53.4
7	Culture	33.33
	Average	50.93
	Sustainability Status	Moderate Sustainable

Source: MSA Software Output Analysis Results.

3.2. Scenario Models to Improve Farm Sustainability in the Food Estate Program in North Sumatra

The study aims to simulate three different scenarios to enhance the sustainability position of further education farms. The design of these scenario models presents an actionable plan that could be executed by the government. Three scenarios have been developed based on several assumptions, specifically through the increase in scores on indicators previously at zero (Table 2).

Table 2. Sustainability status of FE farms in three scenarios.

No	Aspects	Existing	1st Scenario	2nd Scenario	3rd Scenario
1	Economy	47.57	66.57	54.71	71.43
2	Social	50	50	50	72.17
3	Environment	72.22	72.22	72.22	72.22
4	Institutions	50	50	50	73.4
5	Technology	50	50	50	66.71
6	Marketing	53.4	53.4	53.4	83.4
7	Culture	33.33	33.33	55.5	55.5
	Average	50.93	53.65	55.12	70.69
	Sustainability Status	Moderate Sustainable	Moderate Sustainable	Moderate Sustainable	High Sustainable

Source: MSA Software Output Analysis Results.

The first scenario entails solely enhancing economic facets while ignoring other factors. The second scenario involves only enhancing cultural aspects. The third scenario entails enhancing the rating of indicators with a zero value in every sustainability category.

4. Discussion

4.1. Sustainability Status

4.1.1. Economy Aspect

The economic sustainability of FE farming is rated relatively low with a score of 47.57 based on seven aspects. Two indicators require attention as their scores are very low: the absence of a processing industry and agricultural insurance. Their presence is crucial for the sustainability of farming. The processing industry and insurance are linked to market availability and preventative measures in case of crop failure.

The role of the farming processing industry is to accommodate farmers' production and create value-added products. This industry is closely linked to agriculture [18,19]. Moreover, it can also stimulate farmers to adopt new technologies aimed at boosting productivity, increasing agricultural production and income, as well as enhancing the quality of infrastructure, such as roads and electricity [20].

Farmers sell their crops to fresh produce wholesalers. The wholesalers then sell to retailers, markets or direct consumers. To reduce the risk of farmer losses due to crop failure, agricultural insurance is crucial. Agricultural insurance plays a crucial role in enhancing farmers' independence to improve welfare, shielding them from failed harvests and low prices, developing agricultural financing, increasing their ability to undertake more productive and sustainable farming activities, and providing legal certainty for farming activities [21]. Despite its immense benefits, agricultural insurance remains largely unknown to farmers, necessitating extensive socialisation efforts to raise awareness.

4.1.2. Social Aspect

The sustainability status of the social aspects of FE farming is moderately ranked at a score of 50. There are six indicators utilized to assess the sustainability of social aspects. Social aspects, including education level [22], access to infrastructure and transport [23], and farmer knowledge [24], influence the success of farming. On average, FE farmers completed 11 years of education, indicating that they graduated from junior high school. Compared to the average education of Indonesian farmers in 2021, 31.61 percent did not complete school, 31.9 percent completed primary school, 19.26 percent completed junior high school, 15.09 completed high school and 2.14 percent completed university [25]. This indicates that the mean educational attainment of FE farmers surpasses that of Indonesian farmers [25]. This indicates that the mean educational attainment of FE farmers surpasses that of Indonesian farmers.

Access to transportation plays a crucial role in farming activities. FE farming transport uses its own vehicle to access the site, which benefits from asphalted roads in Ria-Ria Village, enabling farmers to easily transport goods to and from the land. Addition-

ally, [26] states that adequate farming roads offer advantages such as reduced transportation costs, improved accessibility during the rainy season, and facilitating quality, quantity, and sustainability.

The consideration of farmers' knowledge of sustainable agricultural methods is crucial as it impacts their motivation for farming activities [27]. The knowledge of sustainable agriculture activities amongst FE farmers can be enhanced through participation in group activities alongside support from extension workers. Additionally, [28] extension activities can significantly increase farm productivity.

4.1.3. Environment Aspect

The environmental aspect of FE farming has a sustainability score of 72.22, based on nine indicators. Farming practices have a direct impact on the environment through the use of fertilisers and pesticides, which can affect the quality of soil [29] and air [30].

Farming activities carried out by FE farmers have prioritised environmental considerations, such as following recommended guidelines for the use of organic and inorganic fertilisers and pesticides, crop rotation, assessing land suitability, and ensuring water availability. These activities are accomplished well by FE farmers as they possess an average of 11 years of farming experience.

FE farmers utilise organic fertilisers such as chicken or cow compost, which minimises the expenditure associated with the purchase of chemical fertilisers that have become more expensive. The reasons for the rise in chemical fertilisers are the global surge in energy prices, high demand, logistics costs, and political problems in the producing nations of the world [31]. These exorbitant prices have prompted a reduction in chemical fertiliser use, which has resulted in the impairment of crop production [32,33].

FE farmers are familiar with crop rotation and its associated benefits such as reducing the development of plant pests and diseases [34] and improving soil structure [35]. They typically rotate up to three crops, such as chillies followed by cabbage and potatoes, accounting for price fluctuations and weather conditions and land suitability.

4.1.4. Institution Aspect

The institutional aspect of FE farming has a moderate sustainability score of 50. This aspect includes five indicators: availability of capital institutions, extension frequency, farmer groups, land conversion extension, and conflicts within farmer groups. Farmers in this institution are subject to activities that support farming success.

Capital institutions accessible by FE farmers include cooperatives, microfinance institutions, and conventional banks, which play a significant role in strengthening farmers' capital [36]. Nevertheless, many farmers remain hesitant to borrow money for farming from these institutions, primarily due to concerns over their ability to repay the loan capital.

The presence of farmer groups is useful for extension. Agricultural extension workers disseminate technological information for farmers to adopt. However, farmers are hesitant to adopt novel technologies. Low levels of technology adoption by farmers may be attributed to factors such as farm distance, educational attainment, land area, and access to sources of technology [37].

Farmer organisations often encounter conflicts or challenges between members as part of their group dynamics. However, it is crucial to control these dynamics to ensure continued activity, progress, and development for the group. Farmer groups consisting of FE farmers receive government subsidies, which is why they become members of these groups.

4.1.5. Technology Aspect

The technology aspect of FE farming's sustainability status is moderate with a score of 50. The technology aspect comprises seven indicators. Two indicators of internet access were directly asked of farmers, and a questionnaire was administered to the Humbang Hasundutan agriculture office for five additional indicators on technology adoption.

The impact of communication networks and internet access in rural areas has led to an increased number of farmers turning to online sources for information related to agricultural advancements and commodity prices. A study has shown that the utilisation of internet services can positively impact farm income [38].

Adopting technology by farmers requires time and persuasion. Extension workers play a crucial role in assisting farmers. Increasing the frequency of meetings between extension workers and farmers could encourage them to improve cultivation using more efficient technology. Increasing the frequency of meetings between extension workers and farmers could encourage them to improve cultivation using more efficient technology. Increasing the frequency of meetings between extension workers and farmers could encourage them to improve cultivation using more efficient technology. For instance, information and communication technology is significant for decision-making, which can enhance farmers' economic conditions [39].

4.1.6. Marketing Aspect

Farm production increases but the absence of a market that accommodates production will harm farmers because they cannot sell their crops. The marketing aspect of FE farming has a moderate sustainability score of 53.4, with five indicators including availability of marketing institutions, promotional activities, knowledge of selling prices, relationships with consumers, and sales expertise.

In the initial design of the Farming Enterprise (FE), farmers' crops were directed towards third-party companies for sale. The government has attempted to establish a market, yet the purchasing capacity of the company results in not all crops of the farmers being purchased. Currently, FE farmers sell their produce to intermediaries who come directly to the farmers' fields.

The dominant role of traders has the potential to harm farmers, with negative effects such as having to sell to traders at a lower price [40]. When traders become too dominant, farmers become price takers, so the government needs to provide alternative markets that can accommodate FE farmers' crops. Trust, kinship, profit, and professionalism contribute to the strong bond between farmers and middlemen [41].

4.1.7. Culture Aspect

The cultural aspect of FE farming has a sustainability score of only 33.33, the lowest of all categories assessed. Cultural indicators are deemed essential for evaluating the sustainability status in this area. This aspect comprises six indicators, including communal work, traditions for preserving nature, local wisdom, and understanding of agricultural culture.

Farmers in general believe that the culture of communal work in farming has declined. This trend is not exclusive to farmers in FE. As explained by [42] research, the communal work culture has decreased due to economic factors, people's busy schedules, modernisation (selfishness), and a diminishing sense of togetherness. Therefore, increasing awareness within the community and approaching the community through socialisation and meetings between community leaders is essential for its revival. Research on the value shift of the communal work in the agricultural sector in Sumatra was explained by [43] that the value shift was due to the existence of farm labourers and the development of agricultural mechanisation technology.

Some additional sources claim that cultural comprehension is diminished in rural regions due to the effects of external cultures, formal education systems, attitudes towards valuing the work of others, and the tolerance of social nonconformity [44]. This poses a challenge for the government to rekindle the spirit of social cohesion in agriculture, promoting the preservation of culture and local knowledge.

4.2. Scenario Models to Improve Farm Sustainability in the Food Estate Program in North Sumatra

4.2.1. First Scenario Model: Economic Improvement

The first scenario involves economic improvements through the provision of farming capital, processing industries, and agricultural insurance. Such improvements will increase the value of sustainability status from 50.93 to 53.65 (Table 3). Although the increase in value is only 0.3, it is not significant.

Table 3. Sustainability status of FE farms in the first scenario.

No	Aspects	Existing	1st Scenario
1	Economy	47.57	66.57
2	Social	50	50
3	Environment	72.22	72.22
4	Institutions	50	50
5	Technology	50	50
6	Marketing	53.4	53.4
7	Culture	33.33	33.33
	Average	50.93	53.65
	Sustainability Status	Moderate Sustainable	Moderate Sustainable

Source: MSA Software Output Analysis Results.

The economic aspects can be improved through the use of the model design shown in Figure 1. Such a strategy can be put into action to enhance the sustainability of FE farming. Strategies for implementing the proposed model are outlined below:

- Availability of Agricultural Insurance: The government promotes the utilisation of agricultural insurance services by insurance companies and farmers. They encourage the provision of agricultural insurance services to FE farmers by providing tax deductions for companies. Additionally, the government incentivises FE farmers to use insurance services by offering counselling to socialise the benefits of insurance and subsidising the initial payment of insurance premiums.
- Processing Industry Availability: The food industry collaborates with the government. Incentives such as corporate tax deductions and opportunities to participate in land processing at FE sites are provided to the industry. Regions are classified by the government based on commodity prices, and crops can be marketed or distributed to other regions through Bulog. Through the introduction and adoption of agricultural processing technology, small-scale processing industries can be launched by the government to empower local communities.
- Farming Capital: The government promotes the borrowing of capital by farmers from banks at reduced interest rates. Additionally, loan repayment systems are regulated by the government, in line with the harvest season.

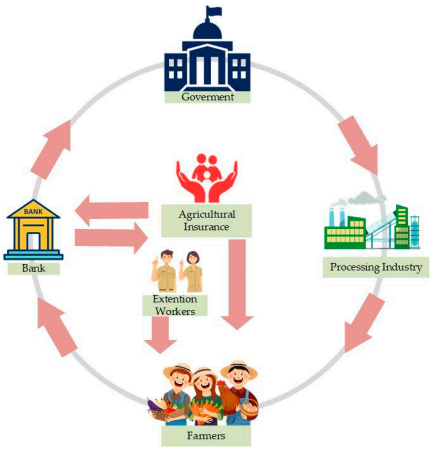

Figure 1. First scenario model design.

The provision of agricultural insurance mitigates potential losses resulting from crop failure, which can occur as a result of various factors. The presence of a processing industry offers farmers a viable market to market their produce, rather than relying on traders. Financial institutions furnish a source of capital for farmers to scale up their agricultural business.

4.2.2. Second Scenario Model: Culture Improvement

Second scenario is by enhancing cultural aspects, such as communal work, agricultural orientation, and understanding. Table 4 indicates that improving these three indicators would increase the sustainability status to 55.12, albeit only by roughly 0.2. Implementing a model design strategy could improve these indicators.

Table 4. Sustainability status of FE farms in the second scenario.

No	Aspects	Existing	2nd Scenario
1	Economy	47.57	54.71
2	Social	50	50
3	Environment	72.22	72.22
4	Institutions	50	50
5	Technology	50	50
6	Marketing	53.4	53.4
7	Culture	33.33	55.5
	Average	50.93	55.12
	Sustainability Status	Moderate Sustainable	Moderate Sustainable

Source: MSA Software Output Analysis Results.

The second scenario, focused on enhancing cultural aspects, can utilize the design model illustrated in Figure 2. This model can serve as a practical approach for enhancing the sustainability of FE farming. The proposed implementation strategy for the model draft is outlined below.

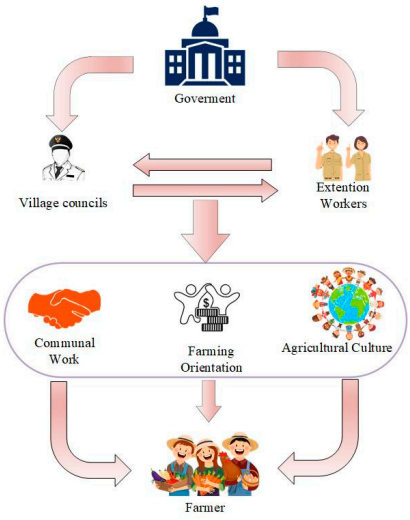

Figure 2. Second scenario model design.

- Communal farming work: (1) The government, through village councils and extension officers, invites farmers and groups to communal work in the cultivation stages by taking turns, such as during land preparation or planting. This can decrease the workload for farmers regarding labour expenses, and (2) communal work can occur on the agricultural land of group members based on the requirements of the farmers.
- Farming orientation: (1) The government requires additional extension workers to facilitate more frequent meetings between farmers and extension workers, and

(2) extension workers play a vital role in providing farmer assistance and promoting a comprehensive understanding of farming practices. As farming practices are largely individualistic, it is imperative to establish active farmer groups to bring about changes in farming practices for the benefit of the community.

- Agricultural cultural knowledge: (1) The location of Humbang Hasundutan in the Lake Toba Region offers potential for holding agritourism events with cultural significance. (2) The government regularly organizes events showcasing local cultural values. The government organises yearly events that celebrate local customs, such as agro-tourism activities during harvest season, where visitors can pick crops alongside farmers. In addition, there are regional cultural events.

4.2.3. Third Scenario Model: Improvement of All Aspects

The third scenario enhanced all aspects except for the environment. The values of the improved indicators remain identical to those in scenarios one and two, with additional improved values in institutional aspects (indicators of frequency of extension, land conversion extension, and farming conflicts), technological aspects (indicators of technology adoption and relevance, and farmers' response to technology), and marketing aspects (indicators of promotion activities, knowledge of fair prices, and consumer relationships). Table 5 demonstrates that subsequent to enhancements made to the indicators regarding the abovementioned aspects, the sustainability status score substantially rose to 70.69.

Table 5. Sustainability status of FE farms in the third scenario.

No	Aspects	Existing	3rd Scenario
1	Economy	47.57	71.43
2	Social	50	72.17
3	Environment	72.22	72.22
4	Institutions	50	73.4
5	Technology	50	66.71
6	Marketing	53.4	83.4
7	Culture	33.33	55.5
	Average	50.93	70.69
	Sustainability Status	Moderate Sustainable	High Sustainable

Source: MSA Software Output Analysis Results.

The third scenario for enhancing all aspects could utilise the design model presented in Figure 3. This model can serve as a feasible strategy for enhancing the sustainability of FE agriculture. The implementation tactics for the proposed model are outlined below.

- The first and second scenarios are still implemented.
- Additional activities in the third scenario, involving stakeholders:
    1. The government collaborates with the private sector to offer capital, insurance, and market support for the processing industry. Additionally, the government gives subsidised agricultural inputs, capital, and technology, with a focus on sustainable agriculture. The transfer of knowledge and technology involves village governments and agricultural extension officers.
    2. Farmers are active in group activities to acquire knowledge on sustainable agriculture, technology adoption, communal work and farming culture accompanied by extension workers intensely.
    3. Private enterprises, including banks, cooperatives, and processing industries, receive incentives from the government to offer capital, services, and markets to farmers.

The three scenarios presented can be considered alternative strategies that could be implemented through effective coordination and cooperation between government agencies, private sectors and farmers. The third scenario yields the greatest sustainability

status, suggesting that advancing the sustainability of FE farming requires improvement in multiple aspects rather than just one.

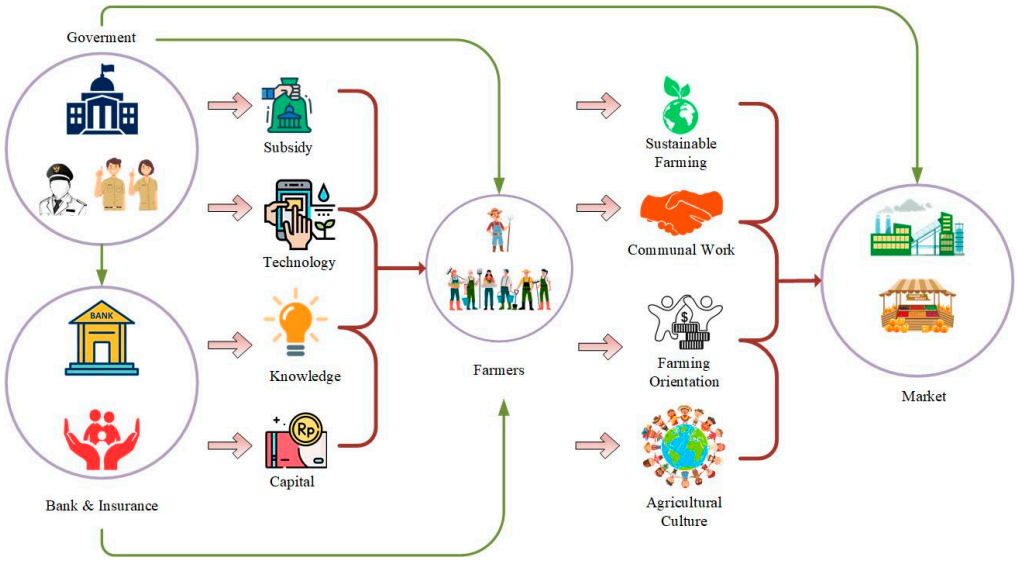

Figure 3. Third scenario model design.

5. Conclusions

The sustainability status of FE farming is generally deemed "moderate sustainable". However, the economy and culture are currently at a "low sustainable" status, while the other five aspects are at a "moderate sustainable" status. Pivotal strategies are required to improve the sustainability status of FE farming. Three scenarios were modelled as feasible strategies: the first scenario sought to enhance economic aspects, the second scenario aimed to improve cultural aspects, and the third scenario aimed to improve all aspects. Both the first and second scenarios resulted in only a slight increase in the sustainability value of FE farming, while the third scenario was able to achieve the highest sustainability value. Technical term abbreviations are explained when first used.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to because this research concerns a national program of strategic importance to the government of Indonesia, which has received a great deal of attention from various parties.

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